THE IDEOLOGIES OF SCIENCE

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Introduction

Writing in *Science* in 1966, the late Homi J. Bhabha, the father of India's nuclear technology, stated a very simple and seemingly convincing notion about the relationships between science and social and economic development. "What the developed countries have and the underdeveloped lack is modern science and an economy based on modern technology. The problem of developing under-developed countries is therefore the problem of establishing modern science in them and transforming their economy to one based on modern science and technology[1]. The detonation of a nuclear device in India, in 1974, and the launching of a satellite the next year, left no doubt as to the success of India's strife for proficiency in some of the most sophisticated areas of modern technology. The question of how far these achievements helped to lead India into a developed economy, however, is much less clear.

The relationships between science, modern technology and development are of course much more complex than what Bhabha's statement would let us suppose. This complexity derives, in fact, from the very complex nature of the host of activities, institutions, and bodies of knowledge that usually are brought together under the term "science." More than that, the perceptions one has of what science is, and how it relates to long-range

[1] Bhabha, H. J., "Science and the Problems of Development, " Science 151, February 4, 1966; 541-584.

processes of social transformation, is usually tainted by a cloud of myths that have always surrounded the scientific activity.[2]

These myths are not to be taken lightly. They are not simple misconceptions that one could expect to be brushed away once knowledge improves and the correct nature of these relationships become established. A myth, according to a standard dictionary definition, is "a usually legendary narrative that presents parts of the beliefs of a people or explains a practice or natural phenomena." The myths about science are one of the ways societies perceive and justify their beliefs in progress, and the way scientists explain and justify their practices. While reality itself is contradictory and complex, the myths are easy to grasp and have a coherence that is more related to the social functions they perform than to the actual canons of formal logic. This means that they do not fit into a coherent picture, but are often contradictory in their assumptions and implications.

A dialectic-like approach seems appropriate to deal with them. Without any claim to dialectic orthodoxy, we shall look first into the general, undifferentiated mythical concept of progress through science, which will be then split into two, a thesis and an antithesis. The thesis is the Myth of the King Philosopher, in which we will discuss the notions of scientific planning and the role of the intellectuals in that. The basic assumption of the thesis is that scientists are a special kind of intellectuals, who are entitled to and actually will run society according to their superior knowledge. The antithesis holds that society tends to rationality on its own, and that the only things scientists must do is to be loyal to themselves. Thus, we will speak of the Kingdom of Science, with a special chapter dedicated to the Republic of Scientists. Finally, there is an attempt of a new synthesis, which is the theory of the identity between science, technology and development.

To point to these myths is not the same as to denounce them as necessarily wrong and misleading. What gives strength to a myth is that it captures a significant portion of the social reality, how it is as well as how people perceive it, and transforms it into a generalized truth. When it is said, for instance, that science and technology are two sides

[2] The illicit but persistent marriage between human rationality, science, and its opposite, myth, has more than once caught the attention of those who look to science through glasses of the social sciences. See, for instance, Kalman H. Silvert, *The Social Reality of Scientific Myth* (New York: American University Field Staff, 1969) and Jean-Jacques Salomon, "Science Policy and Its Myths", *Public Policy*, 1972, 1, pp. 1-33.

of the same coin, the verb "to be" means that this is so, that it should be so, and that it will be so whenever science and technology develop. This combination of empirical, normative and predictive statements is what makes the myths so elusive, but at the same time so immune to empirical or logical disproof.

The introduction of modern science outside the Western world has been as much a consequence of independent social process as a product of political and social will. This is why the myths play, here, such a large role, which we will try to spell out in the remainder of this text.

The Old Synthesis: Progress through Science

Homi Bhabha's statement at the beginning belongs to an old tradition that maintains that science or superior knowledge is good and socially useful, and is a key factor in distinguishing between advanced and backward, primate or barbarian societies. This was clear, it seems, for Jawaharlal Nehru, who is quoted by Bhabha as a strong supporter of science because of its role "not only in transforming the material environment, but in transforming man. It is an inherent obligation of a great country like India, " said Nehru, "with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today."[3]

The idea that Science, with a capital "S", holds the key to the solution to the problems of mankind is not, of course, new. Robert K. Merton, in his classic study on the emergence of modern science in seventeenth century England, shows how the increasing prestige of scientific careers was related, at that time, with the idea that this was both a practical, utilitarian and a noble kind of endeavor. Arithmetic and geometry, for instance, were "most useful for keeping accounts and enabling a gentleman to understand fortifications, " while chemistry was "a piece of knowledge not misbecoming a gentleman."[4] For the Puritan ethics of the time, science, or natural philosophy, "was instrumental first, in establishing practical proofs of the scientist's state of grace; second, in enlarging control

[3] Quoted by Bhabha, ibid., p. 542.

[4] Quoted in Robert K. Merton, *Science, Technology and Society in Seventeenth-Century England*, Harper, 1970, p. 27 (first published in 1930).

of nature; and third, in glorifying God. Science was enlisted in the service of individual, society and deity."[5]We could, of course, look further back for the source of these ideas, if we just remember that, for the Greek philosophers not only was knowledge the most pleasant of the activities, but that, in Plato's Utopia, the Philosopher is King.

This mixture of moral and pragmatic justifications for scientific activities is probably the most important dimension of this scientific myth. It has been, historically, an indispensable ingredient in the culture of all societies where Science has occurred as a significant activity. Sociologists of science like to call "scientism" the social and cultural support for scientific ideals, and there is abundant historical evidence to show that scientism, when it emerges, tends to be part of the ideologies of rising social groups. This was, of course, true in the case of Merton's gentlemen of seventeenth-century England, as it was the case with the French intellectuals in the Eighteenth century, and the Germans in the Nineteenth.[6]

We can leave aside, in this context, the important question of the social determinants of this scientific myth, and see what happens when it is present in a given society. One effect is that some of society's most talented and gifted individuals choose science as a worthwhile area of activity. The other is that the society, as a whole, agrees to pay for the costs of scientific activities. Another characteristic is that science is sought for and supported irrespective of its practical results. It is not that there is no interest or expectations about the products of scientific knowledge; on the contrary, they are a very important component of the myth. But, when the belief is there, the failure to produce practical results in the short or medium run is not enough to reduce the faith in the value of scientific research, for those who do it as well as for those who have staked their support on it. The whole Western history of the last four centuries seems to be a proof of the long term benefits of science research, and this gives an important argument in science's behalf in periods of technological meagerness.

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[5] R. K. Merton, "The Puritan Spur to Science" (initially published as chapter 5 of above) in *The Sociology of Science* (Chicago, 1973), p.232.

[6] For an historical view of scientism and its role in the establishment of scientific activities, see Joseph Ben-David, *The Scientist's Role in Society - A Comparative Study* (Englewood Cliffs: Prentice-Hall, 1971).

A final consequence of the scientific myth is that the term "Science" comes to encompass a multiplicity of different and not always really compatible types of activity. What is and what is not scientific activity is, o course, an extremely complicated epistemological question, which we could not try to approach here.[7] It suffices to use a simple sociological definition - "science is what people who are recognized as scientists do" - to see the complex array of activities that come into the same heading. Natural vs, social, empirical vs. exact, basic vs. applied science, demonstration vs. confirmation, data-gathering vs. theory construction, research vs. development, science vs. technology - all these and other dichotomies describe activities which are very different in goals, styles, methods of verification, criteria of truth and validation. We would also find big differences if we went across disciplines - what is "basic science, " for instance, for a physicist, a botanist, a marine biologist and a geologist? These differences in "working paradigms" are combined with profound differences in the way people organize themselves for the pursuit of their scientific tasks. Universities, autonomous research centers, large-scale industrial laboratories, institutes of technology, academe, the social settings for scientific research can range from small to gigantic, informal to extremely bureaucratized, academic to completely committed to technological results, cost-effective to completely cost-innocent institutions.

Moreover, the myth of progress through science can uncover under its generality and pervasiveness very different and often contradictory assumptions about the relationships between science and society. We can consider these assumptions as mythical in themselves, since they influence how science development is sought for by different people and institutions. One of these myths has to do with the role intellectuals and scientists play in their country's life. The other has to do with the way science, as rational knowledge, makes its presence felt in the social and political realm.

[7] It is enough to refer to the famous Thomas S. Khun vs. K. S. Popper contraposition of the concepts of normal science as puzzle-solving activities within paradigms, on one hand, and the demarcation principle of refutation, on the other, to draw attention to the problem. The basic references are K. R. Popper, *The Logic of Scientific Discovery* (1934, first edition) and *Conjectures and Refutations* (1963); T. S. Khun, *The Structure of Scientific Revolutions* (1962, 1967); and also the participation of Imre Lakatos, *Criticism and the Growth of Knowledge* (with A. Musgrave, 1970).

Thesis: The King Philosopher

a) Scientific planning

Nineteenth century positivism is an excellent expression of the old Platonic's utopia of a Republic rationally organized and ruled by the men of knowledge. In his outline of the *Travaux Scientifiques Nécessaires pour reformer la Société*, Auguste Compte saw the need of two tasks to be performed: "l'une, théorique ou spirituelle, a pour but le développement de l'idée-mère du plan, c'est-a-dire du nouveau principe suivant lequel les relations sociales doivent être coordonnées, et la formation du système d'idées générales destiné a servir de guide a la société. L'autre, pratique et temporelle, détermine le mode de répartition du pouvoir a l'ensemble d'institutions administratives les plus conformés a l'esprit du système, tel qu'il a été arrêté par les travaux théoriques. La seconde série étant fondée sur la première, dont elle n'est que la conséquence et la réalisation, c'est par celle-ci que, de toute nécessité, le travail général doit commencer."[8] The first task is to be given to the scientists, "les hommes que font profession de former des combinaisons théoriques suivies méthodiquement, c'est-à-dire les savants occupés de l'étude des sciences d'observation" (p. 86). The second task, the execution of the plan, could then be given to the managers, or the '"chefs des travaux industriels." The dominance of the intellectual over the practical chores is absolute: "il y a, dans ce travail, une parte spirituelle qui doit être traitée la première, et une partie temporelle qui le sera consécutivement" (p. 88). In a footnote, Comte takes into account the fact that natural scientists are often too limited to their fields of specialization, and talks about "les hommes qui, sans consacrer leur vie à la culture spéciale d'aucune science d'observation, possèdent la capacité scientifique, et ont fait de l'ensemble des connaissances positives une étude assez approfondie pour s'être pénétrés de leur esprit." To these would be reserved "l'activité essentielle dans la formation de la nouvelle doctrine sociale." The other would just have a "passive" role (p. 87).

[8] Auguste Comte, *Plan des Travaux Scientifiques Nécessaires pour Réorganiser la Société* (Paris, Editions Aubier-Montaigne, 1970; first published in 1822), p. 75.

The notion that society should be organized through science is just one step away from the idea that science itself should be subject to the same type of planned organization. Comte himself did not hesitate to make this step, and his mistrust for the scientists who wanted to have their own, independent institutions, is well known. Comte's king philosopher is not a simple scientist, but an intellectual, a man that can go beyond the limits of specific knowledge and attain a grasp of all knowledge, and from there to derive obeisance and acceptance to their supremacy. He talks about "les savants," and stresses that "eux seuls exercent, en matière de théorie, une autorité non contestée .Ainsi, indépendamment de ce que seuls ils son compétents pour former la nouvelle doctrine organique, ils son exclusivement investis de la force morale nécessaire pour en déterminer l'admission" (p. 89). The importance of the positivistic outlook does not lie in its historical truth nor in its practicality, and less so in its originality. Its importance resides in the fact that it synthesizes one of the underlying myths of modern science, and as such has had and still has a great impact. One should look, for instance, at the rather extreme statements put forward a few years ago by Stevan Dedijer on the needs for science in the developing countries:

> "The first effective steps along the road of national development are unthinkable today without using the results of research from the start. It is impossible to estimate your starting degree of development, it is impossible to define your objective, it is impossible to make each step from the first to the second without research in the natural, social and life sciences... The development of a national research potential, i.e., qualified scientists, scientific institutions and equipment and a scientific culture within those circles must be created in order to carry out other national policies with any degrees of effectiveness. Sciences policy must be as important a part of the national development policy as economic and educational policy and, perhaps, mores important than foreign, military and other policies. To neglect a planned and vigorous development of indigenous research in the physical, life and social sciences endangers the whole process of development."[9]

This need for modern science contrasts very sharply, for the same author, with the realities of the developing countries. They lack a scientific community, a government used to deal with science, and "industrial, agricultural, commercial, educational, medical,

[9] Stevan Dedijer, "Underdeveloped Science in Underdeveloped Countries," *Minerva,* II, 1, 1963, p. 64.

military and other institutions that value the results of research." They lack the "institutional and motivational elements for research, " and hence are "basically alien or hostile" to it.

The solution which is presented to solve the problem is planning, which is , of course, made much more difficult because of the very lack of scientific experience and tradition of theses countries. "In underdeveloped countries, ignorance, prejudice and the absence of sources of reasonable advice render such decisions (about science) much more difficult, their success much mores problematic. " These and other problems only lead the author to require more, rather than less, planning: "every decision on science must be part of a national plan for the development and use of the results of research. Sciences must be looked upon as part of a planned national policy. Each primes minister should establish in his offices a secretary for science."

In fact, agencies and ministries for science policy haves developed throughout the world in the last fifteen years, and international institutions likes UNESCO, the Organization for Economic Cooperation and Development, the Organization of American States) and others created their own structures to help in the establishment of the national bureaucracies for science planning. Pew or nones of the most responsible leaders of these organizations would endorse Dedijer's non-qualified and naive optimism on the power of science and the virtues of planning; but they will share the same concern and the same basic distrust about the ability of the scientists themselves to bring to their countries the benefits that they should. Science planning is today but one of the structures of comprehensive planning that haves been established to try to bring development and modernization to the third world. They share, of course, all problems and difficulties that have plagued these structures.[10]

b) The intellectuals

The intellectual's claim to moral superiority and a right to run society is not, of course, something that starts with Comte or even Plato. One of the central themes of Max

[10] For a pessimistic view of the achievements of comprehensive planning in the underdeveloped countries outside the socialist block, see Naomi Caiden and Aaron Wildawsky, *Planning and Budgeting in Poor Countries* (New York, Wiley and Sons, 1974).

Weber's studies on the ancient Chinese, Indian and Jewish societies is the power interplay between the military, that rule by force, and the intellectuals, that try to rule by moral authority.[11]

Historically, intellectuals often emerged as a group specialized in religious matters. As Max Weber pointed out, "at first priesthood itself was the most important career of intellectualism, particularly wherever sacred scriptures existed, which would make it necessary for the priesthood to become a literary guild engaged in the interpreting of the scriptures and teaching their content, meaning and application." This was particularly true, still according to Weber, to India, Egypt, Islam and ancient and medieval Christianity; and less so in Greece, Rome and China, places where "the development of all metaphysical and ethical thought fell into the hands of non-priests, as did the development of theology.[12] In China, Confucianism was a doctrine developed by a bureaucracy of mandarins, with "an absolute lack of feeling of a need for salvation or for any transcendental anchorage for ethics. In its place resides what is substantively an opportunistic and utilitarian (though aesthetically refined) doctrine of conventions appropriate to a bureaucratic status group" (p. 476). In India, the Brahmins developed a secularized religion that suited the conveniences of the ruling Kshatriya nobility, but were able to remain as the holders of the rituals, procedures and norms of behavior that presided over the elite's education and proper conduct. Other forms of religion - more mystical, inward looking, magic or Salvationist - developed when the relations between the sacerdotal and the priestly sectors became less integrated. Buddhism and Jansenism are outstanding examples of Salvationist religions that emerged from the Chinese and Indian traditions, developed within the intellectual groups, and later spread throughout the masses. In ancient Judaism, the disorganization of the State and its priesthood, after Solomon, seems to have given the conditions for the emergence of a popular religion

[11] For a comprehensive interpretation of Weber historical studies of ancient civilizations, see Reinhardt Bendix, *Max Weber - An Intellectual Portrait* (University of California Press, 1978).

[12] Max Weber, *Economy and Society* (New York, Belmister Press, 1968, 3 volumes), p. 500.

based on the prophetic movement and what Weber calls "petty bourgeois and pariah intellectualism," with a strong Salvationist and ethical content.

In other words, intellectuals often are responsible for the development and maintenance of religious or cultural traditions that lend justification and social legitimacy to the social order, and in exchange are granted social honor and prestige, as with the Brahmins and Mandarins. When their prestige is threatened, or when new intellectual groups emerge they tend to develop alternative, "Salvationist" ideologies and religions that often preach detachment from the mundane life and the search for inner truth. The role of scientific, empirically-based knowledge in both instances tends to be minor.

The discussion of the role of intellectuals in the Arab world is very illuminating in this respect. The Muslim religious scholar, the "ulama," traditionally has placed himself close but well differentiated from the holders of political power. Sometime after Muhammad, "the religious scholars realized that by remaining detached from the actual exercise of political power, they retained prestige without being contaminated by the fault of princes and, therefore, could better cultivate their intellectual traditions. A tacit concordat seems to have evolved between the "ulama" and the princes, "that left to the religious scholars the control of matters relating to personal status, education and moral behavior."[13]

The price to be paid for this concordat was a hierarchy of different types of knowledge, which placed at its top the study of religious law, which establishes the proper rules of behavior in society. In second place came the type of knowledge that could be considered socially useful, such as medicine and mathematics (which was needed "to implement the requirements of religious law in certain matters, such as division of estates and bequests and other business transactions"). Finally, less relevant was the knowledge for its own sake, which could be approved only because it could eventually help with the performance of useful social tasks. As Menahem Milson summarizes it, "The order of value seems clear: the non-religious sciences are considered necessary only as applied

[13] Menahem Milson, "Medieval and Modern Intellectual Traditions in the Arab World" (*Daedalus*, Summer of 1972), p. 19. See also Nikki E. Keddie, "Intellectuals in the Modern Middle East: A Brief Historical Consideration, " *ibid*. For a more comprehensive view, see G. E. von Grunebaum, *Modern Islam: The Search for Cultural Identity* (Berkeley: University of California Press, 1962).

sciences and derive their value from advancing the objectives of religious law. The value of pure or basic research is subsumed under applied science, which is itself subservient to religion." This order of priority reflected "the predominance of the 'ulama' as the uncontested intellectual elite of the Islamic society" (p. 78).

This arrangement was not incompatible with the flourishing of applied and scholarly scientific and philosophical work that happened during the medieval times, through which the Islam culture kept and continued the Greek and Roman traditions until the Renaissance. The contacts with the West, however, which intensified after the first military defeats of the Ottoman Empire at the end of the seventeenth century, seemed to have hampered this tradition. Attempts were made to modernize Egypt, Turkey and other Islamic countries, and Western culture provided alternative channels for intellectual development to the traditional "ulama" religious scholarship. These Westernized intellectuals were politically oriented, and often tried to reach into the Islamic past for a bridge between their traditions and the Western ideas and practices, which were often presented as derived from the Arab culture in the first place. The main outcome of this process, however, was not Western science, but political Westernization and Arab nationalism. In this century, "in the thirties and forties the intellectuals led the struggle for independence by means of the written and spoken word. They were in the forefront of the movements which called for complete independence and social reform; many of them were active in political parties and parliament. But once the revolutionary regimes were established by military men, these intellectuals seemed left out. Paradoxically enough, the intense involvement of the modern Arab intellectuals with political ideology may have contributed to their political marginality, once the ideology which they had created triumphed.[14]

The establishment of a Ring Philosopher does not seem to be necessarily, and not even positively related with the development of modern science. On the contrary, the Western experience seems to be the product of a unique arrangement which placed a group of intellectuals in a very special position, outside the centers of power and with a deep commitment to their task. For Weber, the explanation goes back to the "pariah

[14] Milson, op. cit., p. 33.

intellectualism" of ancient Judaism, which develops historically into the personal ethics of "salvation through the believer's efforts," of which the Protestant ethics and Western rationality are the culmination. Joseph Ben-David, in the same vein, discusses the traditional roles of philosophers and magicians in traditional societies, and the question he is concerned with is similar to Weber's: how can one account for the combination of rationality, individual intellectual drive and concern with the nature of things that are the characteristics of modern science.

"The traditional philosopher," says Ben-David, "like the scientist, is interested in grasping, by means of logical models, some kind of 'reality.' But the paradigmatic reality for the traditional philosopher was man and/or God. Natural events were not considered as important as human (or religious) affairs..."[15] From this point of view, practical knowledge is seen as a lesser kind of endeavor, where the search for practical results could easily give rise to the magic world of astrology, alchemy and shaman medicine. As Ben-David had shown, the path that led to the development of science as an institutionalized activity that deals with nature according to the higher principles of reason has been difficult and irregular. It required the creation of a special role for the scientists in society, which was different from the one of priest-philosopher, as well as the one of the magician-practitioner: before science could become institutionalized there had to emerge a view that scientific knowledge for its own sake was good for society in the same sense that moral philosophy was. His work had to be approved and supported, but, in order to flourish, the scientists should only serve Science, the same that the capitalist entrepreneur should only serve the requirements of self-fulfillment through profit and entrepreneurship. Paradoxically, according to the logic of liberalism, this was, for both, the best way of serving Humanity and God.

Antithesis: The Kingdom of Science

a) The rationalization of society

It should be clear by now that the Platonic ideal of the King philosopher, as well as the Comtian ideal of the supremacy of "les savants, " does not belong to the modern

[15] Joseph Ben-David, *The Scientist's Role in Society* (Englewood Cliffs: Prentice-Hall, 1971), p. 29.

mythology of scientism. The liberal notion of development through rationality is essentially individualistic, and it assumes that, the same as with the market, society will be more rational and efficient if each person behaves rationally, and if the irrational and limiting norms of behavior and institutions that curtail individual initiative are set aside.

It is not a coincidence that Robert K. Merton, following the Weberian path, sought to establish the links between scientistic ideals and Protestantism, as an ethics of individual salvation through ascetism and self-fulfillment. It will be a mistake to believe that the Weberian model of rational-legal authority through bureaucratic administration is a departure from this view. For Weber, legal, rational bureaucracies are rational in a formal sense, that is, they are geared to the maximization of politically defined goals that are set outside their administrative realm. The essence of this type of organization is, in Weber's words, "the belief in the legality of enacted rules and the right of those elevated to authority under such rules to issue commands"[16] Whenever this formal rationality conflicts with the substantive goals of the administration, the first is to prevail, since it is the formal, legal rationality that gives to the rest of society the conditions for predictability in the exercise of their private, individually oriented rational actions.

The notion that science, and the scientist (or, in Plato's time, the philosopher) should govern and impose the principles of rationality upon society is radically distinct, in that it implies a quite different social role for the scientist, and a profoundly different way of social organization, in which rational planning takes the place of the free flow of individual rationality.

The Kingdom of Science is, therefore, in its liberal version, an inseparable part of the eighteenth and nineteenth-century ideals of evolution and progress through the development of individual reason and rationality. One of its central postulates is the radical belief that each person is entitled to accept or reject truth according to his inner convictions, and that scientific knowledge should prevail because it was inherently better and more convincing than conventional wisdom. In this sense, rationalism was in political terms a libertarian ideology that challenged the traditional organization of societies and their systems of power and authority. The political significance of this

[16] *Economy and Society*, p. 215.

ideology is much stronger, of course, when their supporters are intellectuals, university students or other social groups that have a very definite stake in social change.

Russia in the nineteenth century is an excellent example of this libertarian function of the scientistic ideology. In his study on *Science in Russian Culture*, Alexander Vucinich gives a picture of the ideological and political climate which surrounded the ideas of science at the time. A group of intellectuals of the 1860's, among them D. I. Pisarev, N. A. Dobroliubov and N. G. Chernyshevskii, were the center of a movement known as "Nihilism, " which was an explicit and coherent defense of the intellectual power of science and the humanistic qualities of the scientific attitude."[17]

Referring to another contemporary, M. A. Antonovich, Vucinich says that "he saw in the omnipotence of science a guide to a better way of life. His idea that all the sciences were part of the same logical continuum led him to justify the application of natural scientific methods to the study of society, history and the human mind. His philosophy was a thinly veiled attack on contemporary theological thought as the ideological arm of a social system based on autocracy, widespread illiteracy and serfdom (...) The materialistic concept of the unity of science, the historical relativity of scientific laws, and the intellectual superiority of the scientific spirit were parts of a new ideology, which undermined the autocratic system and speeded its downfall" (p. 20). In its purest form, this ideology did not lead simply to the rejection of the Russian established authority, but of authority as such. A law professor at the St. Petersburg University is quoted as saying to his students that the universities were places where "every authority is pushed aside, so that the truth can begin to speak for itself. In its modern orientation, science is independent, just as truth is independent; it stands above all external interests, all biases and prejudices (...) it is fearless (...). and self-purposeful (...) it operates on the principle that truth, which includes everything rational, must be given practical application sooner or later" (p. 43). The authorities' reaction to this was, of course, negative, although they were themselves convinced of the benefits that science could bring to them. Summing up his work, Vucinich says in his introduction that "the government saw science as indispensable to the modernization of Russia's economy, armed forces and the public

[17] Alexander S. Vucinich, *Science in Russian Culture* (Stanford, 1963), p. 15.

services"; but it also "distrusted the scientific spirit, with its critical attitude towards authority, its relativistic interpretation of nature and social institutions, its individualistic approach to problems, and its belief in the supreme wisdom of man's rational capacities. The authorities had good reason for their distrust, since nearly all the regime's leading opponents explicitly expected science to play a major role in liberating Russia from the feudal past and introducing an age of civil liberty, social equality and freedom of thought."

This does not mean, of course, that all scientists shared the same belief. It is not a coincidence that some of the most outspoken supporters of science as an instrument for social change and modernization were not natural scientists, but philosophers, law professors, intellectuals. The traditional St. Petersburg Academy of Sciences, founded in the early eighteenth century, had a vested interest in science as an independent and pure intellectual activity. In doing that, the Academicians opposed both the adoption of new scientific ideas and the social and political ideologies that accompanied them. In the universities, however, the drive for modernization and change was much more intense: "university professors were more in tune with the great changes of the sixties and seventies; to them, the search for knowledge and the active diffusion of modern ideas were vital tasks of immediate social importance. It was the university professor rather than the Academician who introduced Darwinism to Russian audiences, made the names of Liebig, Bunsen, Helmholtz, and Ludwig as respected in Russia as they were in Germany (...) It was the professor, not the Academician, who helped science to reach the larger community as both a body of knowledge and a powerful ideological weapon" (pp. 75-76). It is an irony that it was the Academy, and not the universities, that provided the basis for the Soviet scientific establishment of today.

b) The Republic of Science

"The Republic of Science, ' said Michael Polanyi, "is a Republic of Explorers.[18] "They explore the unknown, and are committed only to their curiosity and to the search for

[18] M. Polanyi, "The Republic of Science, Its Political and Economic Theory" in *Minerva,* I, 1, 1962. Cf. also "The Growth of Science in Society" in *Minerva,* IV, 4, 1967; and his major work on the subject, *Personal Knowledge - Towards a Post-Critical Philosophy* (London: Routledge and Kegan Paul, 1958).

intellectual satisfaction. They are not loyal to God, country nor wealth, but only to themselves. Each one is free to follow his inner drives. As in a market place, they "sell" their products as publications, and are "paid"' in terms of academic prestige and influence. As in the market, individual rationality leads the scientist to work in the topics that are more valuable, that is, that give more prestige, and in which have more comparative advantages, in terms of previous background and intellectual skills. If he fails in choosing the most rational topic for research, he will soon be expelled from the market by the competition. Thus, the Republic of Science fosters individual rationality, and in doing so, it fosters science as a whole. The aggregation of so many individual decisions does not result in chaos, but in coherence: a scientific community is organized through the principles of "self-coordination by mutual adjustment" and "discipline under mutual authority." This community develops, through the rules of the market, common notions of what is important and what is not, which patterns of behavior are acceptable and which are not and which are the problems worthwhile pursuing. In other and more fashionable words, they develop a common paradigm.

The conceptual attractiveness of the myth of the Republic of Science stems from the intellectual elegance that comes with the market-like model of social integration; in the real world, it is a good defense of the scientific community against those that try to tell them what to do. According to this perspective, only the scientists know what should be done in their research, and the adjustment between the products of their work and the intellectual and material needs of mankind will naturally happen, as a matter of course.

It is important to bear in mind that this conception corresponds to the historical reality of a scientific community that, as Derek de Sola Price has shown, grows geometrically and doubles its size every ten to twenty years.[19] All the notions of freedom of research, predominance of truth over authority, support for innovation and creativity, are closely related with the existence of an expanding frontier of more people, more resources, and more jobs. Science suffers when the limits for expansion are approached, and questions of priority, precedence, social relevance, and seniority start to emerge. In global terms, only the recent years seem to be bringing the endless expansion for scientific activities to

[19] D. J. de Sola Price, *Little Science, Big Science* (New York: Columbia University Press, 1963).

a halt; particular cases of scientific centers that reach their prime and deteriorate for the lack of room or resources to expand are abundant. In these cases, however, the historian of science tends to look the other way, to those that had picked up the banner of continuous growth and progress. The scientific myth illuminates success and progress, and eschews stagnation and failure. The myth brings also the notion that "there is only one science," which helps to avoid the problems of priorities and choices that are not necessary when expansion is continuous.

This assumption can have several different meanings. Here, we are referring to the idea that science is universal, that medicine, physics, chemistry or political science have no nationality or ideological creed. For this to be correct, one would need to have an international scientific community coordinated by market-like rules in a context of perfect information, in which the production of the best scientific work would be the currency to bring people to the highest levels of prestige, control of resources and authority. However, the post face to the second edition of Khun's book seems to be enough to show that this Republic does not exist. At closer inspection, scientific communities in the more strict sense are very small groups, knowledge is hardly transferable and understandable from one area of specialty to the other, and scientific research, traditions, styles and emphasis are much less coherent within any given discipline than what the notion of universal science would require. The expansion and sophistication of the modern systems of scientific information have created problems of information overload that tend to limit still further the possibilities a scientist has of following what is happening outside his own field of specialization. As a surrogate for integration and coherence of whole scientific fields, one tends to look at what is being done at the most prestigious scientific centers and published in the main scientific journals for an idea of where the frontiers of scientific activities are.

The way science operates in a context of expanding resources was expressed with all its clarity in a statement of the panel headed by Emanuel R. Piore which in 1958 reviewed the programs of High Energy Physics in the United States: "It is not possible to assign relative priorities to various fields of basic science nor should they be placed in

competition. Each science, at any given time, faces a set of critical problems that require solutions for continued growth. Sometimes these solutions can be acquired at little cost; sometimes larger expenditures of funds are needed. Hence, the cost may not reflect the relative value but rather the need. Each area should be funded according to these needs"[20]

In fact, of course, this logic of the market does not rule over the decisions on resource allocation for science, the same as the logic of free competition does not rule over the distribution of wealth in society. Greensberg's book on the politics of pure science in the United States shows how, in science as in other fields, resources are distributed according to the power and influence of different interest groups as well as political criteria that have little to do with a clear notion of where the "critical problems" are. The myth of a scientific market of "critical problems" comes under stress when science ceases to be cheap and becomes big and expensive, as it has been happening in the fields of particle physics or the more applied areas of space technology and cancer research Since the problems of choice cannot be ignored, there is a tendency to look for science itself as the source for their solution, in a movement that comes close to the Kingdom of Science. Nowhere is this attempt to plan science more explicit and naive than among those that want to bring it to the virgin soil of the developing countries.

The new synthesis: science, technology and economic development

The contrast between the myth of the King Philosopher and the myth of the Kingdom of Science points to two profoundly different perceptions of what rationality is and how, in the future, it should and would be related to society. In the first case, rationality is the gift of intellectuals, a product of their minds, which should be brought to society in a systematic and deliberate way. In the second, rationality is immanent to social processes, and therefore should be left to flourish and prevail by its inner strength and the laws of historical development. They share a common Hegelian conception of historical development through the progressive unfolding of Reason. But while in the first thesis rationality should be part of a conscious master plan for the ordering of society, in the second the development towards rationality is expected to be natural, pre-ordained and

[20] Piori Panel Report, 1958, *High Energy Physics Program*, p.138. Quoted by Daniel S. Greenberg, *The Politics of Pure Science* (New York, The New American Library, 1967), p. 231-2).

unavoidable. The first myth is often used to justify ideologies of comprehensive planning and Systems of technocratic political domination; the second functions often as ideologies of social, economic and political liberalism and laissez-faire.

Seen from this perspective, it becomes clear that the contrasts between the two myths of science are nothing but another chapter of much broader questions of social organization, political freedom and economic planning, that are the main dilemmas of our time. There are no easy conceptual or practical solutions to them: this is, after all, what a dilemma is all about. But it is possible to try to solve them at the level of myths. The new synthesis, in fact, supposes that science, social engineering, technology, economic development, all these forms of modern rationality are just parts of one and the same thing.

Philosophers used to interpret the world, but what matters is to transform it. With a stroke, Marx denounced the alienated character of abstract, independent and theoretical thinking, and threw intellectuals, philosophers and scientists into the political arena. Rationality was a product of social development, which produced modern capitalism and was to produce socialism. Superior knowledge was a function of being for or against history, for development or for stagnation. The frontiers between natural and social sciences, practical and theoretical thinking, abstract and applied work, were all alienations, bound to disappear in the very process of social transformation which was to bring substantive, rather than formal democracy, and concrete, rather than abstract knowledge.

In a perceptive article written in the still optimistic year of 1961, David E. Apter remarked how intellectuals and scientists were both distrusted in the developing countries that were just trying their first steps. "The intellectuals are suspect: they are politically unreliable; they arc afraid of drastic social engineering, particularly when they are unduly apprehensive over the protection of individual liberty." The scientists did not fare better: "they are also isolated. They create science but they do not apply it. Their world is the laboratory and the university. It is the technicians and the entrepreneurs who transform basic science into the practical products of the world."

The strength of Marxism as a political ideology in these countries was that it claimed to bridge the gap between the cultural values of the intellectuals and the practical powers of

empirical knowledge. "Insofar as Marxism is a philosophy of science, it is also a philosophy of social engineering and can therefore be thrust into the heart of a country such as China to destroy the past in the name of the future - a process which is also going on in China." Social engineers and practitioners could bring to these societies their minimum of social and economic organization, from which a better future could eventually be built. He perceived a hope for a new culture to emerge in these countries, based upon a humanistic science, which could blend "the knowledge of science and the knowledge of social morality." The search for elusive entities as "negritude" or the "African personality" was perceived as utopian ideologies that could help to bring this future. But he conceded that the odds were not favorable, because the leadership in these countries were not "with the men of science or the literary intellectuals but with the technicians and politicians determined to build viable societies."[21]

The fusion of all dimensions of rationality in one unit, to be embodied by the revolutionary movements and their leaders, left Marxism particularly disarmed to deal with the problems of technocratic rule, political authoritarianism and over-bureaucratization which plagued the Soviet Union and other socialist societies. What happened, of course, was that Socialism did not emerge, as Marx expected, from the groins of Capitalism, and the intellectual disarray to have to deal with Socialism in a single, underdeveloped country is still being felt. This is, as a matter of fact, the main reason why so many well-meant intellectuals - East or West - refused to accept, for so long, the facts of Stalinism.

It is possible to say that the liberal, non-Marxist theories of social progress were not in a much better position to deal with the facts of the modern forms of technocracy and authoritarianism. Max Weber, as we have seen, shared with Marx the Hegelian heritage that expected rationality to emerge from advanced capitalism. He was less optimistic, however, and forebode a future in which modern bureaucracy would take the reins of political control in its teeth and bring the modern countries back to the patrimonial bureaucratic structures of the Empires of the past. There was no place in his system of

[21] David E. Apter, "New Nations and the Scientific Revolution" in *Bulletin of the Atomic Scientists,* vol. 17, Feb 1961, pp. 60-64.

thought, as there is not in the Western liberal tradition, for the notion of modernization and the introduction of rationality that could come about outside the prescribed roads of capitalist development.[22]

However, after Keynes, economic planning became respectable in the Western world, and the planning of science and education was conceived as a part of it. With the works of Theodore Shultz and others, technology began to be considered as a factor of production on equal footing with labor and capital, and the concept of "human capital" was put forth, as embodying the skills and the knowledge that educated and well-trained people brought to economic development. It became theoretically possible to calculate how much a country should invest in education in order to increase productivity.[23]

Since estimations of the relative size of pure and applied science research budgets and human resources can be derived from the experience of the developed countries, they tended to be used as a rationale for resource allocation in different areas of professional, technical and scientific education. Thus, planning for science, technology and education was conceived as amenable to incorporation in models for economic development, and neo-liberal economic theories joined Marxism in the attempt to build a bridge between the two poles of the antinomy that contrasted the King Philosopher and the Kingdom of Science. A basic tenet of both is the identification between science and technology, which should be seen in some detail.

What is science and what is technology, and how they influence each other, is one of those conceptual problems that seem to have no solution and have no purpose besides keeping some writers busy with hair-splitting questions. Scientists usually know what they do without much questioning, and tend to use the term "science" as an all-embracing concept to describe the whole field of technical knowledge and its applications.

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[22] For an expanded discussion of this, see S. Schwartzman, "Back to Weber: Patrimonialism and Corporatism in the Seventies" by James E. Malloy, editor, *Authoritarianism and Corporatism in Latin America*. Pittsburgh: University of Pittsburgh Press, 1977.

[23] Theodore W. Shultz, *The Human Capital*. See also Frederick H. Harbison and Charles A. Myers, *Education, Manpower and Economic Growth* (New York, McGraw Hill, 1964), and two publications from the OECD, *Forecasting Educational Needs for Economic and Social Development and Planning Education for Economic and Social Development*, by Herbert S. Parnes (Paris, 1962). Por a discussion of these concepts and the analysis of the Indian experience on the subject, cf. Trilok N. Dhar, *The Politics of Manpower Training: Graduate Unemployment and the Planning*

Economists often assume that science is a kind of lateral or preliminary dimension of technology, and tend to refer mostly to the latter, or to Research & Development, as a unified concept that can, supposedly, be seen and understood from the standpoint of economic rationality. Their views are, of course, based on correct readings of important aspects of the historical reality. Their lack of concern about the differentiation between science and technology, however, is telling.

We should probably start by saying that there is no simple and meaningful answer to these questions. Otto Mayr, in a recent article, has shown how the very concept of "science" can change from one time to another, from one language and culture to another, in such a way that "Wissenschaft," for instance, has several connotations that the English word "science" does not.[24] At the same time, historiography has examples to show how technology, as practical knowledge, can develop either from "scientific" knowledge (that is, knowledge developed without direct practical purposes) or without it; and vice-versa. It is possible to make some very specific statements about the relations between science and technology - for instance, contemporary atomic technology is definitely a product of the Second World War, based on scientific knowledge developed in the previous decades; on the other hand, the steam engine of James Watt is from 1769, while the laws of thermodynamics, that presumably explain it, were only put forth by Rudolph Clausius, Maxwell and others after 1850. The general question of how knowledge is transferred from one group and sphere of activity to another is never simple, and duplications, redundancies, things that "work" without "proper" knowledge for their reason, branches of knowledge that are developed without any perspective of practical utilization, all are daily events in the world of science and technology, with no pre-established rules about their short- or long-range integration and coherence. Contrary to what is usually held, practical results are not necessarily the main reason for the scientists' choice of their problems, nor for the support they receive.[25]

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[24] Otto Mayr, "The Science-Technology Relationship as an Historiographic Problem", *Technology and Culture*, vol. 17, 4, 1976.

[25] The history of Enrico Fermi's research group in Italy in the 30's shows that support for their work was asked for, among other things, in the name of the possible benefits of his research. In practice, however, the only drive of the group was to stand up to the well-established research centers in England, Germany, Denmark and the United States in terms of their scientific achievements. More important than the practical

Once it is realized that this is so, it becomes obvious that the question of the relations between science and technology is less an empirical problem than a ideological, or normative one; it implies a debate that has been more or less implicit for many years in the literature of science development of the last decades.

The dominant view in this debate is that there is no substantial differentiation between science and technology to justify their treatment as separate and independent phenomena. An extreme example of this view appears in a recent Soviet publication, which begins with the assertion that "the scientific and technological revolution which manifested itself in the mid-twentieth century grew out of the entire preceding course of development of the world's productive forces." Two pages later, it is said that "a characteristic feature of modern science is its industrialization and dependence on the equipment, apparatus, materials and other means supplied by technology for success in research and experimentation. Science and technology have always been very closely connected; throughout history they have mutually influenced each other."[26] From this point on, science and technology are taken as a unit, for a rather general discussion of problems of economic development in the capitalist world.

Jean-Jacques Salomon holds a similar, although more sophisticated, view. For him, the division between science and technology is a thing of the past, which reflected the old aristocratic disdain for manual labor, and thus placed the intellectual activity in a socially superior level than that of the practical chores. In Europe of the seventeenth century, he says, there was still a differentiation between "cette science que consiste a contempler (qui) est réservée aux 'hommes libres', qui font ouvre 'libérale' ", and the activities of the technician, or craftsman; and, "comme la technique est au dessous de la science, 1'artisan est au-dessous de l'homme libre qu'est le savant".[27] The contemporary nature of science, still for Salomon, was clearly stated by Descartes in his advice to Cardinal Richelieu: "il faudrait que M. le Cardinal vous eut laisse deux ou trois des ses millions, pour pouvoir

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results of their research was, for Fascist Italy, what Fermi's scientific achievements could mean for the glory of the country. Gerald Holton, "Striking Gold in Science: Fermi's Group and the Recapture of Italy's Place in Physics" in *Minerva* XII, 2, April, 1974.

[26]A. Shpirt, *The Scientific and Technological Revolution and the Third World*. Moscow: Novosti Press Agency Publishing House, 1972, pp. 3 and 5.

[27] Jean-Jacques Salomon, *Science et Politique* (Paris, Seuil, 1970), p. 36.

faire toutes les expériences que seraient nécessaires pour découvrir la nature particulière de chaque corps; et je ne doute pas qu'on ne peut venir a des grandes connaissances, que seraient bien plus utiles au public que toutes les victoires qu'on peut gagner en faisant la guerre.[28]

These two references, selected more or less at random, suffice to typify the view: science and technology are related and often indistinguishable activities, and they should be explained, understood and dealt with in terms of their usefulness for society's goals.[29]

Economic rationality seems, at the first glance, to bring support to this view. In fact, the adoption of labor saving techniques can be expected to result from decisions of private entrepreneurs in situations of labor scarcity and market competition. In a classic study on the economies of nineteenth-century England and the United States, H. J. Habakkuk weighs the impact of these elements with the effects of capital accumulation in affording opportunities for new methods and techniques to be experimented in the industrial sector of the two countries. It would be impossible to reproduce here the essential ideas of his study, but the final conclusion is clear: he talks about the stocks of ideas available for technological innovations at the time, about the quality of the educational systems and the skilled labor they provided, and about how political, social, and psychological factors can influence the economic efforts in the two countries. He admits that these factors could have important effects, but at the end he concludes that the relative lag of Britain in regard to the United States at the time could be explained "by economic circumstances, by the complexity of her industrial structure and the slow growth of her output, and ultimately by her early and long sustained start as an industrial power."[30]

The generalization of this conclusion to other cultural, political and social contexts could never be done in face of Habakkuk's cautious contention that non-economic influences are not the best explanation for "Britain and the U.S.A. in the later nineteenth century."

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[28] Quoted by A. Salomon, ibid, p. 38.

[29] The main proponent of this view is, of course, the British scientist, J. J. Bernal, whose opus magnus, *Science in History,* is probably the most ambitious attempt ever made to place the whole evolution of human science in its historical, political, and economic context with varying degrees of successes and failures (those being the sections dealing with sciences in the Soviet Union and with the social sciences.

[30] H. J. Habakkuk, *American and British Technology in the Nineteenth Century - The Search for Labour-Saving Inventions* (Cambridge, at the University Press, 1967), p. 220.

And even if it could, it could never be construed as to warrant the theories of economic development through technology and educational planning.

The stand that scientists take regarding this view is often ambiguous. Whenever resources are needed, the argument for the broader usefulness of science appears.[31] Less selfishly, since the Second World War a growing number of scientists have become impatient and unwilling to accept the social and political aloofness implied in the ideals of pure and independent research, as an irresponsible and hypocritical posture.[32]

Before the war, however, the defense of independent and autonomous science was perceived by many as an important stand in the struggle of freedom of thought and rationality that was threatened by fascism. In a paper published in 1938, Robert R. Merton takes Nazi Germany as an example of social hostility toward science, which in essence "called upon to relinquish adherence to all institutional norms that, in the opinion of political authorities, conflict with those of the State. The norms of the scientific ethos must be sacrificed, insofar as they demand a repudiation of the politically imposed criteria of scientific validity or of scientific worth."[33] The attempts of some German scientists to remain away from the political realities around them only led to passive collaboration, in a context of dwindling freedom and independence. Others left the country, while some jumped onto the bandwagon of national socialism.

Nazi Germany is obviously an extreme case which, seen in retrospect, left no room for scientific life with a minimum of integrity and coherence.[34] Merton's conclusion, however, is more general: "as long as the locus of social power resides in any other institution other than science and as long as scientists themselves are uncertain of their

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[31] Cf. Daniel S. Greenberg, *The Politics of Pure Science* (New York: The New American Library, 1967), for the United States.

[32] For the reaction of the American Scientific community to the atomic bomb, see Alice Kimball Smith, *A Peril and a Hope* (Chicago: Chicago University Press, 1966).

[33] Robert K. Merton, "Science and the Social Order", *Philosophy of Science*, 5 (1938): 32137. Reprinted in R. K. Merton, *The Sociology of Science (*Chicago: The University of Chicago Press, 1973), pp. 254-266.

[34] Alan D. Beyerchen, *Scientists Under Hitler: Politics and the Physics Community in the Third Reich* (New Haven: Yale University Press, 1977). For the previous period, Brigitte Schroeder-Gudehus, "The Argument for the Self- Government and Public Support of Science in Weimar Germany" in *Minerva* X, 4; 537-570.

primary loyalty, their position becomes tenuous and uncertain".[35] As a reaction to the attacks on science, he resorts to extreme liberal myth, which is the one of the Republic of Science.

The search for a middle ground between total subordination of science to technological and political objectives and the total independence of science research has led to attempts to devise "rational" criteria for allocation of resources between the different types of scientific activity. This discussion is well portrayed in the articles brought together by Edward Shils in 1968, which started a debate that could not be reproduced here.[36] Jean- S Jacques Salomon, in a detailed criticism of Alvin Weinberg's suggested criteria for choice in resources allocation,[37] asks himself about "what, in sum, is the source for the mythical hope of objective and rational criteria of choice for the allocation of resources to sciences." He shows, quite convincingly, that there is no way of determining the impact of science on economic development in an historical perspective, and that "even if such a relation could be established, it would still have to be explained in what conditions the overall research effort, and more especially non-oriented research, influences economic growth. The mythology in which science policies are immersed cannot conceal the fact that there is no necessary relation between a country's prosperity and the size of its research expenditure" (p. 31).

Salomon's conclusion is that the decisions to support science are basically political, and are inseparable from the question of the value society places in science research per se, as well as from the power of the scientific community as a pressure group. The appeal for "rational," utilitarian criteria for the determination of science policy is something scientists do in order to gain support for their independent activities; or, in his word, "the legitimacy of science conceived as a value in itself is masked by its recognition as an exchange value." In conclusion, he exhorts the scientists to give up the myths of the Kingdom of Science, without, however, taking refuge in their Republic: scientists are

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[35] Op. cit., p. 266.

[36] *Criteria for Scientific Development: Public Policy and National Goals: A Selection of Articles from Minerva* (Cambridge, Mass.: MIT Press, 1968).

[37] Alvin Weinberg, "Criteria for Scientific Choice" in E. Shils, *op. cit.*; Jean-Jacques Salomon, "Science Policy and Its Myths: The Allocation of Resources", *Public Policy,* XX, 1, Winter, 1972.

citizens like everybody, and they could "change the orientation of the research effort and make it more rational and more in line with the universal intentions of scientific discourse, not by influencing the research system as a means at the service of the state, but by influencing the ends of the state themselves" (p. 33).

It is doubtful that science could survive without its myths, the driving force that provides flesh, blood and passion to an increasingly difficult and expensive kind of endeavor. But it is good advice to take the myths for what they are - hopes, wishes, ideal types - so that reality can appear, instead of its shadow.